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How To

Identify Ozone Injury on Eastern Forest Bioindicator Plants

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Introduction

Ozone [O_3] is an air pollutant (in the lower atmosphere) formed from the reactions of hydrocarbons and nitrous oxides in the presence of sunlight. Automobile engines and industrial processes produce most of the compounds that result in ozone. Natural sources of ozone exist, but they are minor compared to those resulting from man-made sources. The ozone in the upper atmosphere is the same chemical compound, but serves as a protective layer that shields the Earth from harmful ultraviolet rays.

There is increasing concern about how lower atmospheric ozone is influencing the health of our forests. One way to assess the impact is to document visible injury on sensitive plant species, known as bioindicators. Bioindicators are plants that show a well-defined and consistent response to elevated ozone concentrations in the air. This brochure will help you identify ozone injury on the leaves of sensitive plants.

Impacts of Ozone on the Forest Ecosystem

From July through September in the Eastern United States, many plant species that are sensitive to ozone will show visible injury on the upper leaf surfaces (figure 1). Normally, the ozone-injured leaf surfaces of bioindicator plants show stippled discoloration. Discoloration will vary among species, ranging from red to purple to brown. These plants may also drop their leaves early. In addition to visible symptoms, studies have shown that plants affected by ozone are smaller, and may produce fewer healthy seeds. Ozone injury may

stress plants in other ways, and they may become more susceptible to other problems, such as insects and diseases.

Why do we see wide differences in ozone injury among sensitive plants? The answer lies in their maturity, genetic differences, and where they are growing (especially important is soil moisture availability). Therefore, you may find a plant with no symptoms growing next to a severely-injured plant of the same species. By documenting visible symptoms on sensitive plants, we gain information on air quality and possible long-term effects of ozone on forest ecosystems.

Figure 1.—Ozone injury on blackberry leaves.

Steps for Diagnosing Ozone Injury on Selected Eastern Forest Bioindicator Plants

1. **Look for ozone injury during the mid- to late summer.** In the East, the best time to observe injury is between mid-July and mid-September. At higher elevations, however, ozone injury may be masked by early fall coloration.

2. **Find an opening with full sunlight exposure.** Good places to look for ozone injury on bioindicator plants are openings away from major paved roads and power lines. Examples of openings include clearings for wildlife, old meadows, and recently harvested areas (figure 2). The bioindicator plants to look for include blackberry (second-year canes), black cherry, common milkweed, green ash, yellow-poplar, and white ash.

Figure 2.—Example of a suitable opening to look for ozone injury on bioindicator plants.

3. **Select areas with no obvious conditions that would cause mimicking symptoms of ozone injury.** Examples include herbicide applications and mechanical or physical damage. Determine the presence of herbicide or other damaging agent if many plant species in the area (in addition to bioindicator plants) show the same symptoms. These types of areas should be avoided during surveys.

4. **Look for symptoms on mature leaves that are in full sunlight.** The leaves must be exposed to the sun to reveal injury. Symptoms should appear over most of the plant that is in full sunlight, rather than on just one or two branches or leaves. It is easiest to examine plants for which at least 25 percent of the foliage is within your reach (figure 3).

Figure 3.—Black cherry leaves with ozone injury.

- **The typical symptom of ozone is an upper leaf surface interveinal stipple.** Stipple is the discoloration of small groups of cells between the veins, appearing as uniformly sized red to brown spots (figure 4).

Figure 4.—Yellow-poplar leaf with interveinal stipple.

4. (Cont.)

- **The ozone injury pattern normally does not go through to the underside of the leaf** (figure 5). If the injury pattern carries through to the underside, then the injury on the upper surface is probably caused by something other than ozone, such as insects, disease, or weather-related factors.

Figure 5.—White ash leaf showing injury on the upper surface but not on the underside.

- **Older leaves show injury.** Look for injury on the more mature foliage. There should be an increase in severity of injury from the youngest to the oldest leaves (figure 6). Sometimes, young leaves look sunburned and have an overall red appearance. This is not due to ozone.

Figure 6.—Milkweed leaves with more ozone injury on lower, more mature leaves.

- **Shaded portions of overlapped leaves do not show visible ozone injury.** If you move a leaf with ozone injury that is overlapping another leaf with injury, you should see no injury on the lower leaf where the top leaf covered it (figure 7).

Figure 7.—Absence of injury on the shaded portion of exposed leaf.

- **Leaves may show signs of premature aging.** Some plants respond to ozone by dropping their injured leaves (figure 8). Check on the ground beneath the plant to confirm if there is ozone injury on the fallen leaves.

Figure 8.—Early leaf drop of ozone-injured leaves on yellow-poplar.

5. **Does the bioindicator plant you are evaluating fit these criteria?** Have you considered site factors and other agents that can cause mimicking symptoms? If so, you may feel confident that you are observing ozone injury! (figure 9)

Figure 9.—Blackberry leaves with ozone injury.

List of selected eastern forest bioindicator plants and most common visible symptoms of ozone injury:

Blackberry, secondary canes (*Rubus spp.*): Red to purple stipple.
Black cherry (*Prunus serotina*): Red to purple stipple, may drop the injured leaves early.
Common milkweed (*Asclepias syriaca*): Purple to black stipple, leaves may be chlorotic (yellow).
Yellow-poplar (*Liriodendron tulipifera*): Brown stipple, may drop the injured leaves early.
White ash (*Fraxinus americana*): Red to brown stipple. Similar injury is also found on **green ash** (*Fraxinus pennsylvanica*).

Quantifying Ozone Injury on Plants

There are a number of ways to assess ozone injury on bioindicator plants. One method is to document the presence or absence on a predetermined number of plants in a given area. Another method is to quantify the amount and severity of injury that is present on leaves or plants. Amount and severity of injury are generally evaluated on a percent scale to obtain precise estimates of ozone injury. Changes in the ratio of injured to uninjured plants or in the amount and severity of injury can provide an indication of changes in air quality and injury conditions for a given area.

Reference

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